Problem Set 5

Physics 363 Spring Quarter 2008 H.J.Frisch HEP320 (702-7479)
Apr. 30, 2008 Due in class Wed. May 7.

Reading: Perkins Chapter 5, Sections 5.3 to end. You may want to look up d-functions in Rose.

Problems: (this set is long- please start early, and work together.

1. Derive the total cross-section for $e^+e^- \rightarrow \mu^+\mu^-$ scattering via one-photon exchange (ignore the Z):
   (a) first ignoring the spins of the electrons and muons,
   (b) and then summing over spin states.
   (c) Evaluate this cross-section at a c.m. energies of 3, 90, and 500 GeV (note that at 90 and 500 one shouldn't ignore the Z, but this is the one-photon contribution ignoring interference.).
   (d) What fraction of muon pairs will be created with a c.m. angle beyond 30 degrees from the beam line?

2. Derive Equations 5.14 and 5.16.

3. Derive the differential cross-sections $d\sigma/dq^2$ and $d\sigma/dcos(\theta)$, and the total cross-section σ, assuming $q^2 << M_W^2$:
   (a) for $\nu_e/e \rightarrow \nu_e/e$ scattering (Equations 5.24)
   (b) for $\bar{\nu_e}e \rightarrow \bar{\nu_e}e$ scattering (Equation 5.26)
   (c) Draw a plot of the differential cross-sections versus θ for $\nu_e/e \rightarrow \nu_e/e$ and $\bar{\nu_e}e \rightarrow \bar{\nu_e}e$.

4. Derive the differential cross-sections for neutrino-nucleon scattering:
   (a) In terms of the u-quark and d-quark distributions in x: (Equations 5.40 and 5.41).
   (b) In terms of F_2 and F_3 (Equ. 5.44)
   (c) In terms of the integral quark and anti-quark momentum fractions (Equ.s 5.45-5.47).

5. Derive the Gottfried sum rule.

6. Derive the Gross Llewellyn-Smith sum rule.

7. Perkins Problem 5.4

8. Perkins Problem 5.7